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GB 1218292
GB 1139048
GB 656784
GB 595474
GB 497477

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(54) Moulding Paste

(57) A moulding paste, comprising an aqueous suspension of a fibrous or particulate material particularly newsprint pulp, and a water-binding material such as starch, which

chemically binds substantially all of the water present.

The paste can be used to produce formed articles such as paper plates and tubes by techniques such as injection moulding, and extrusion, without de-watering in the die or nozzle.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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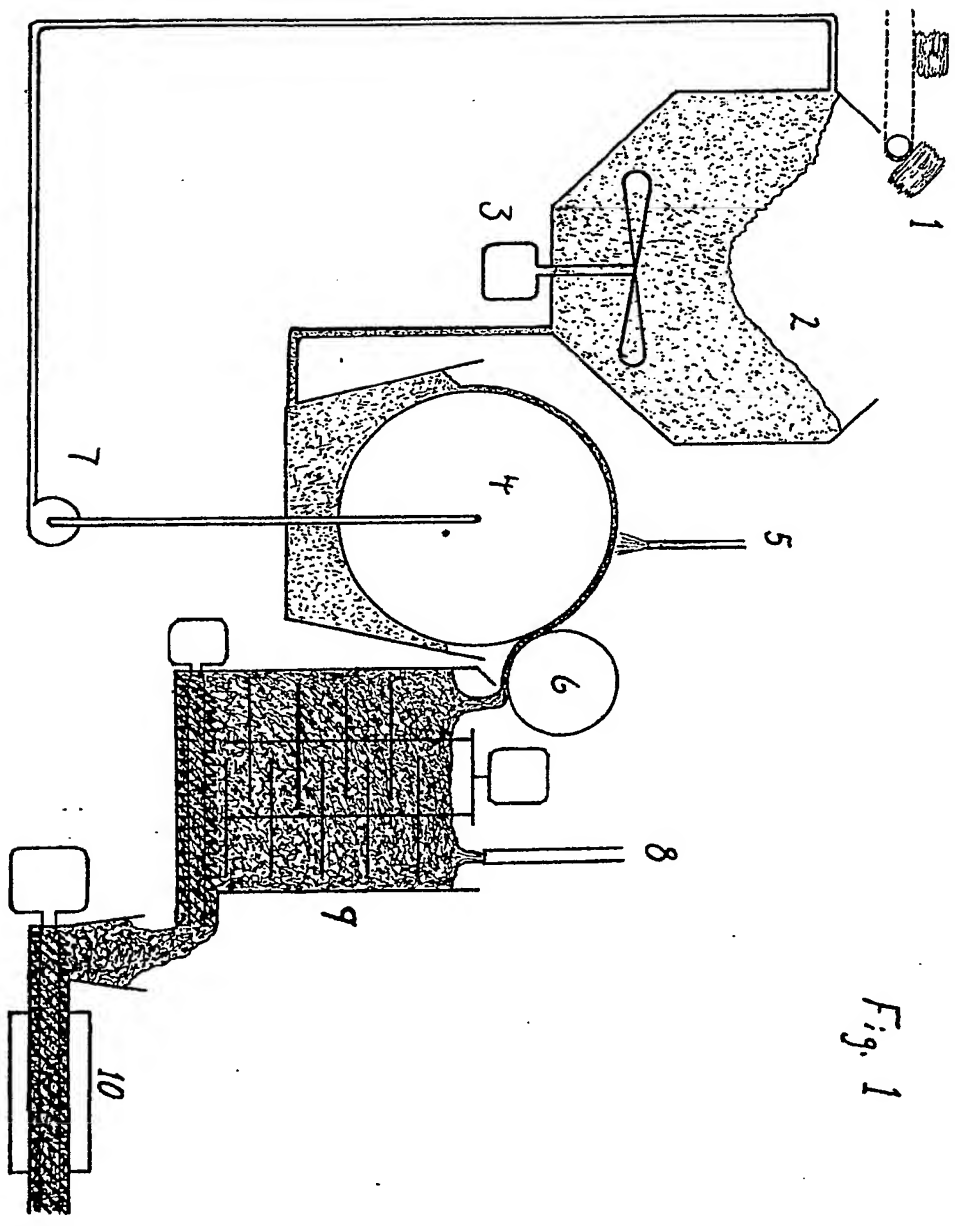


Fig. 1

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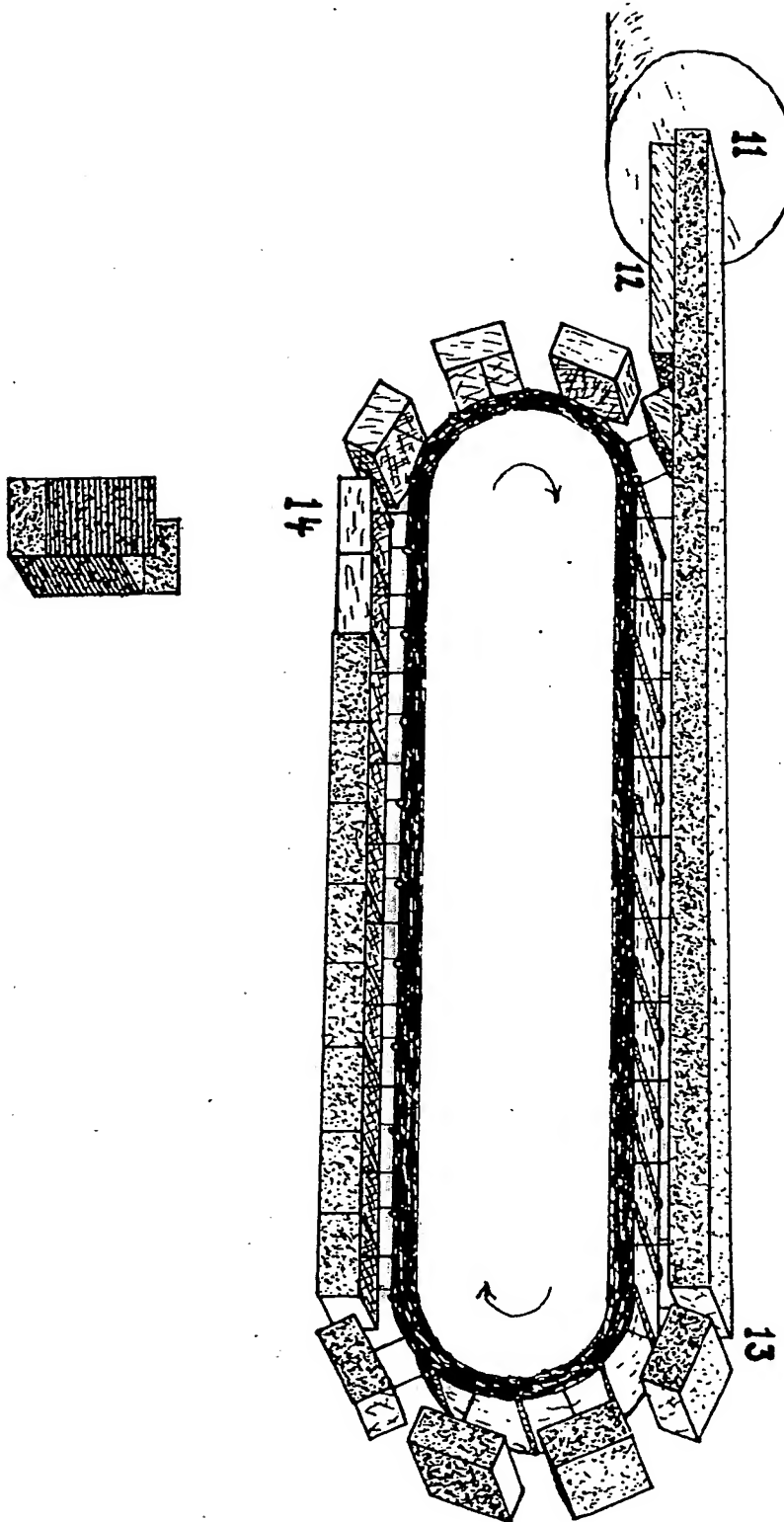
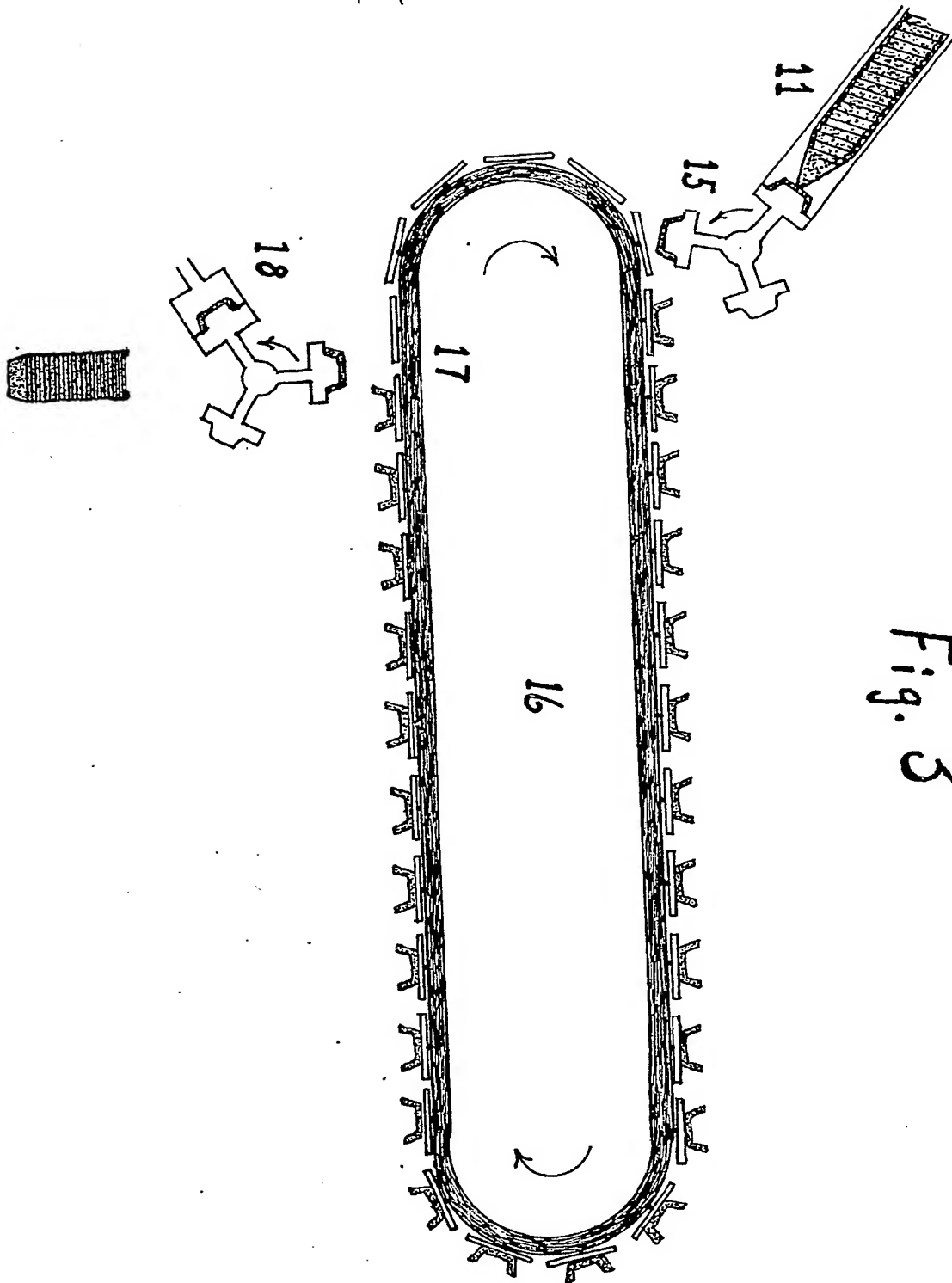


Fig. 2

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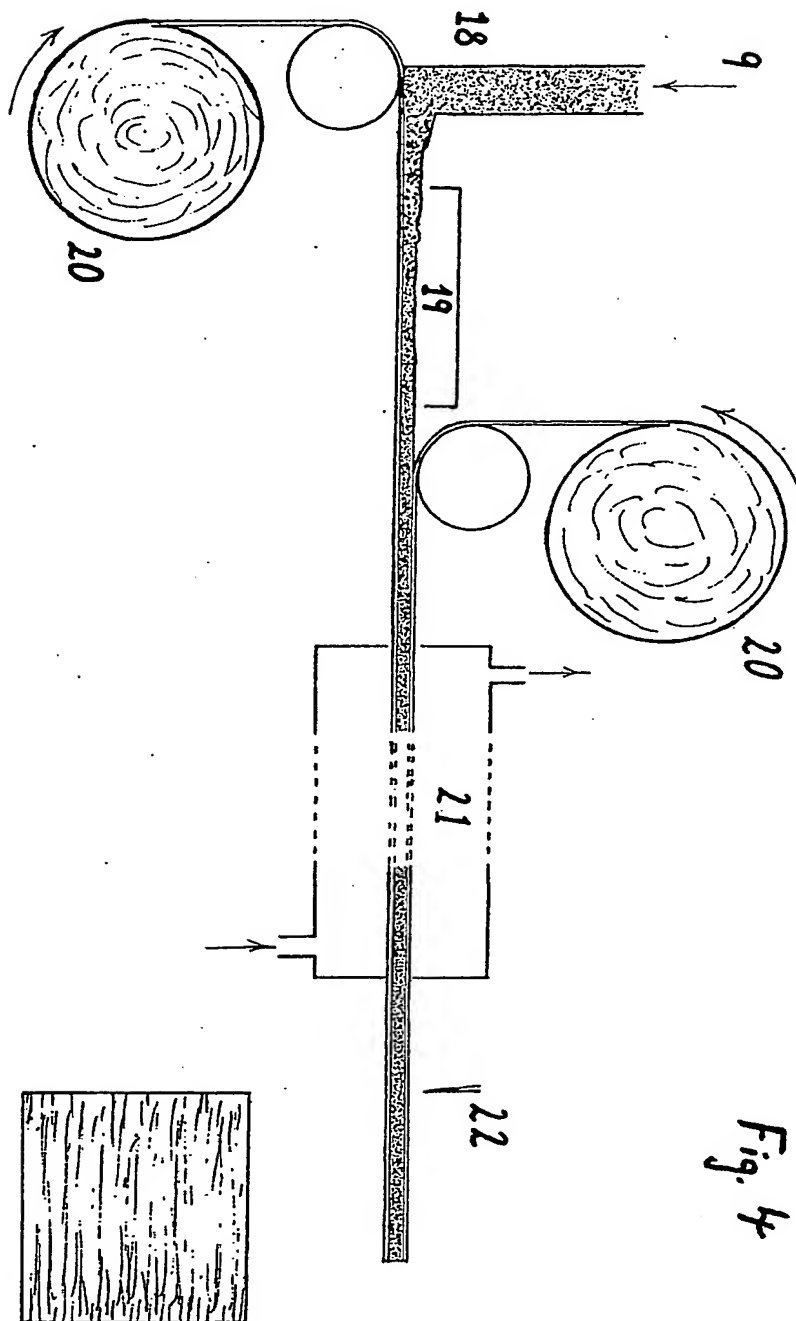


Fig. 4

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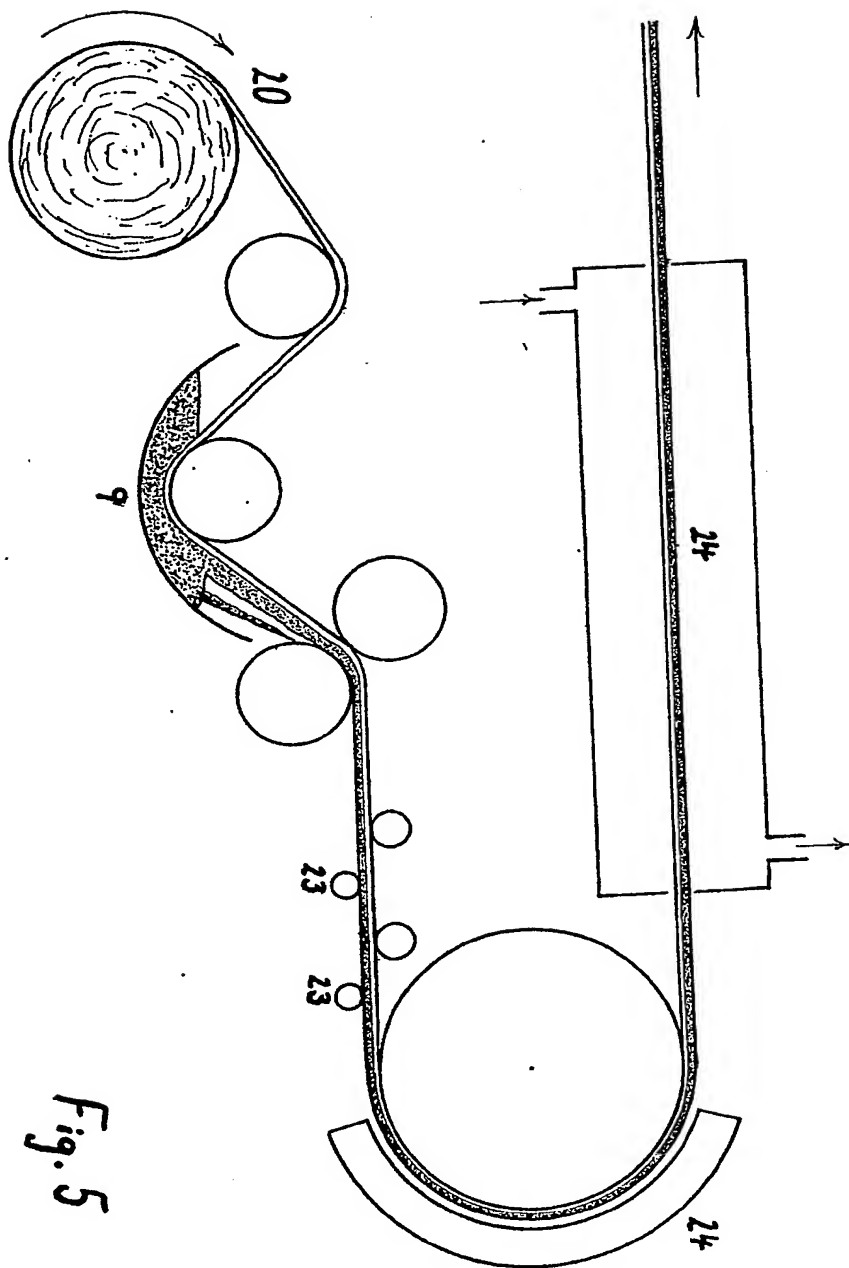
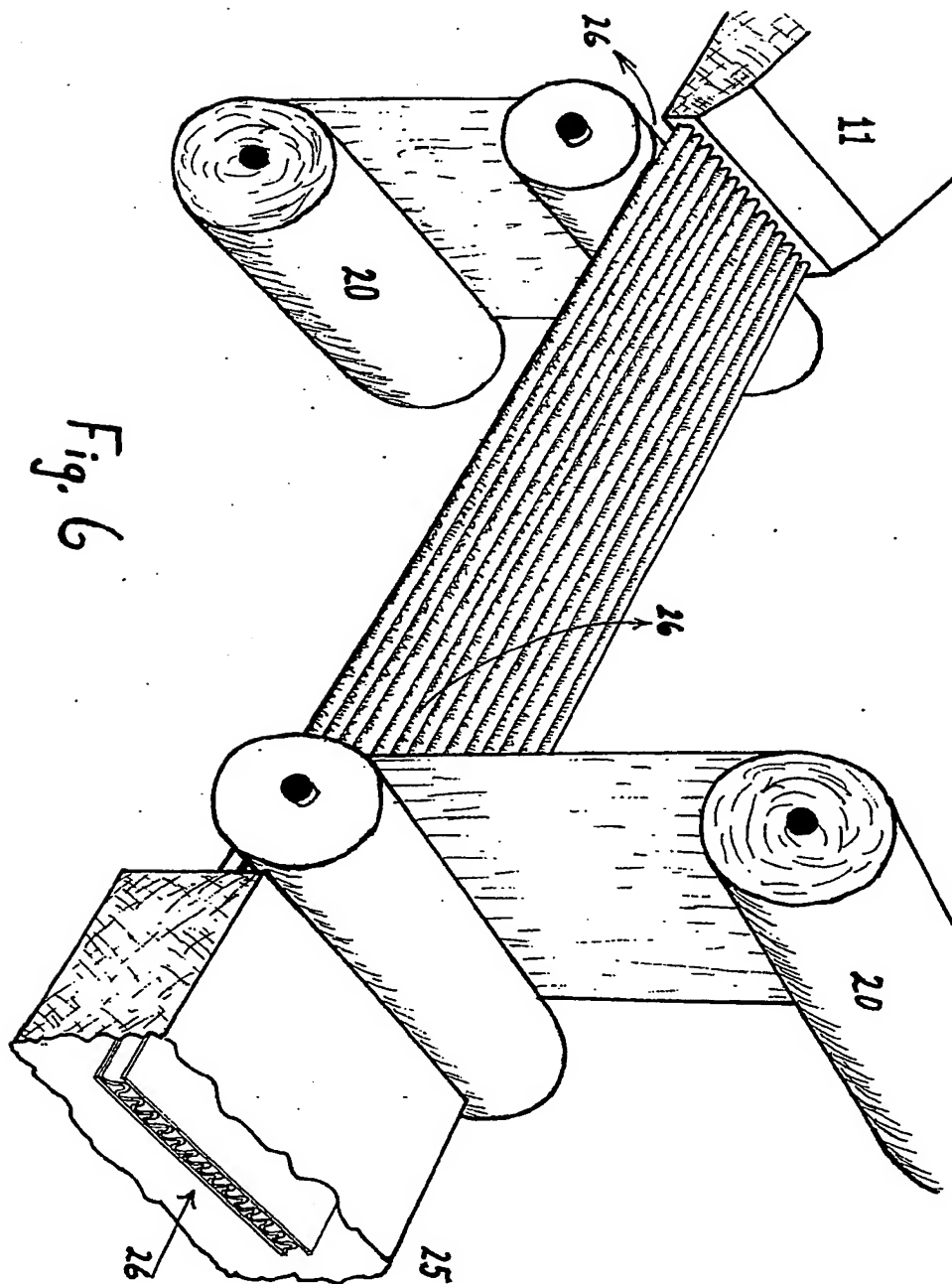


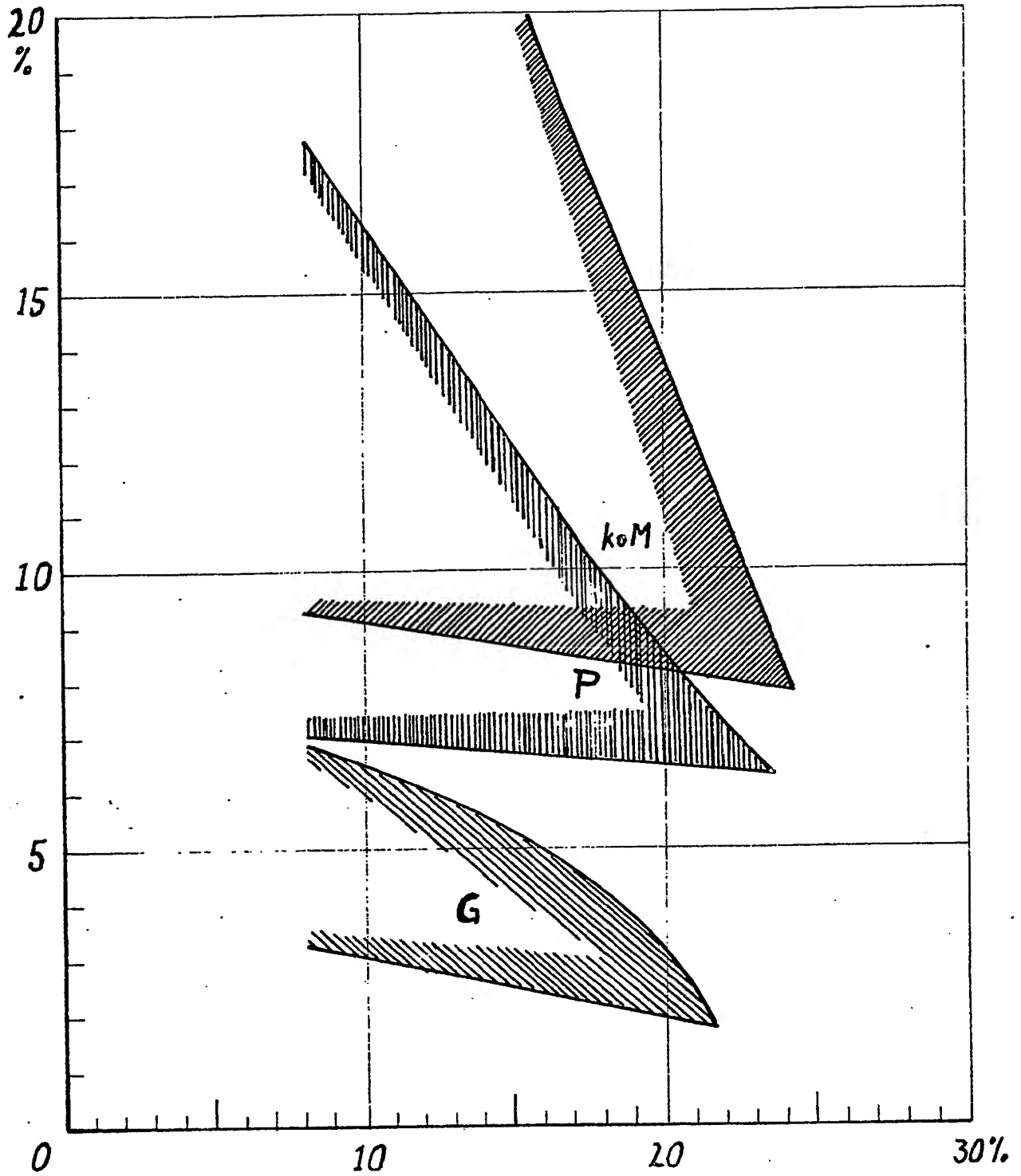
Fig. 5

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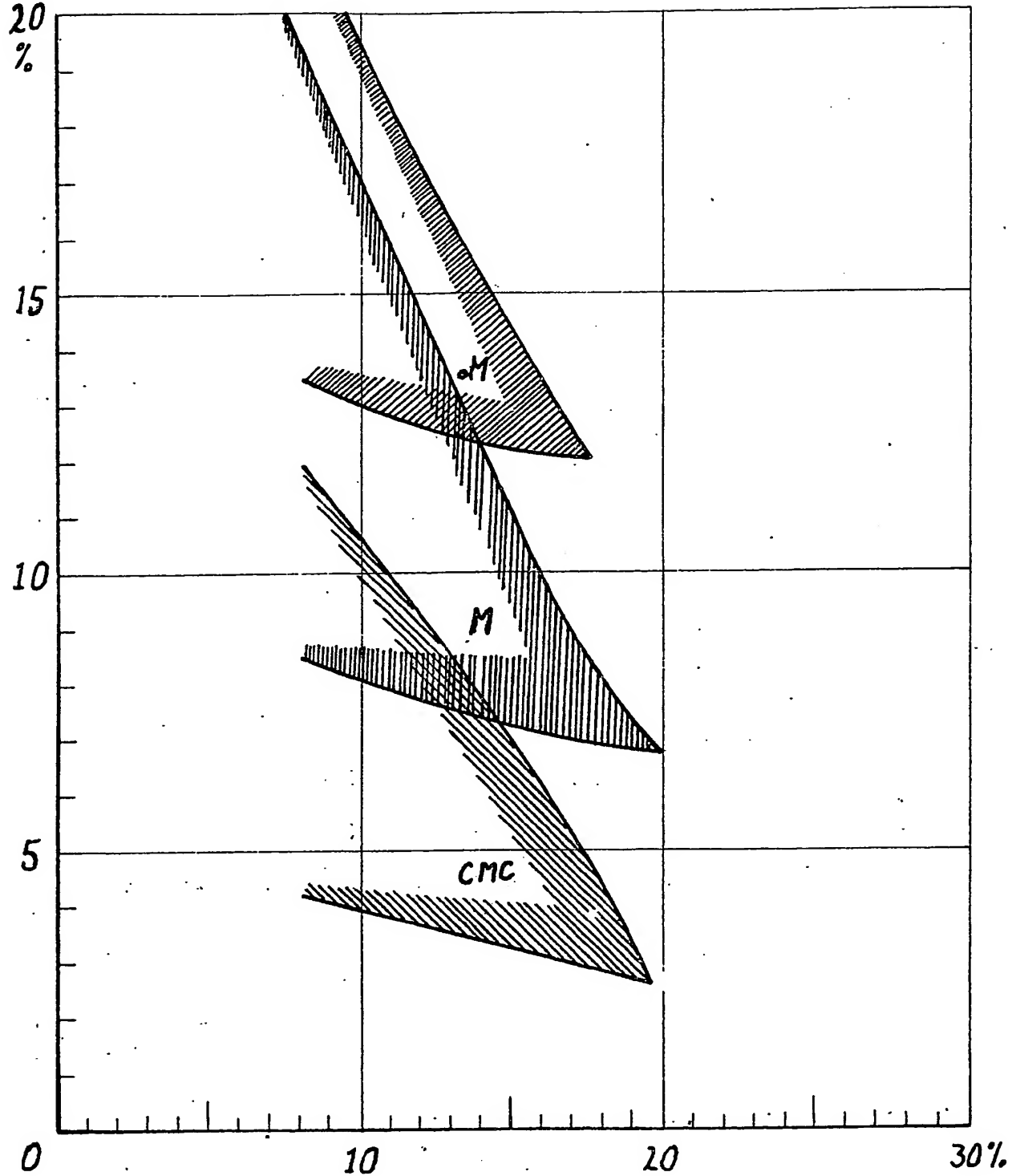
Fig. 7



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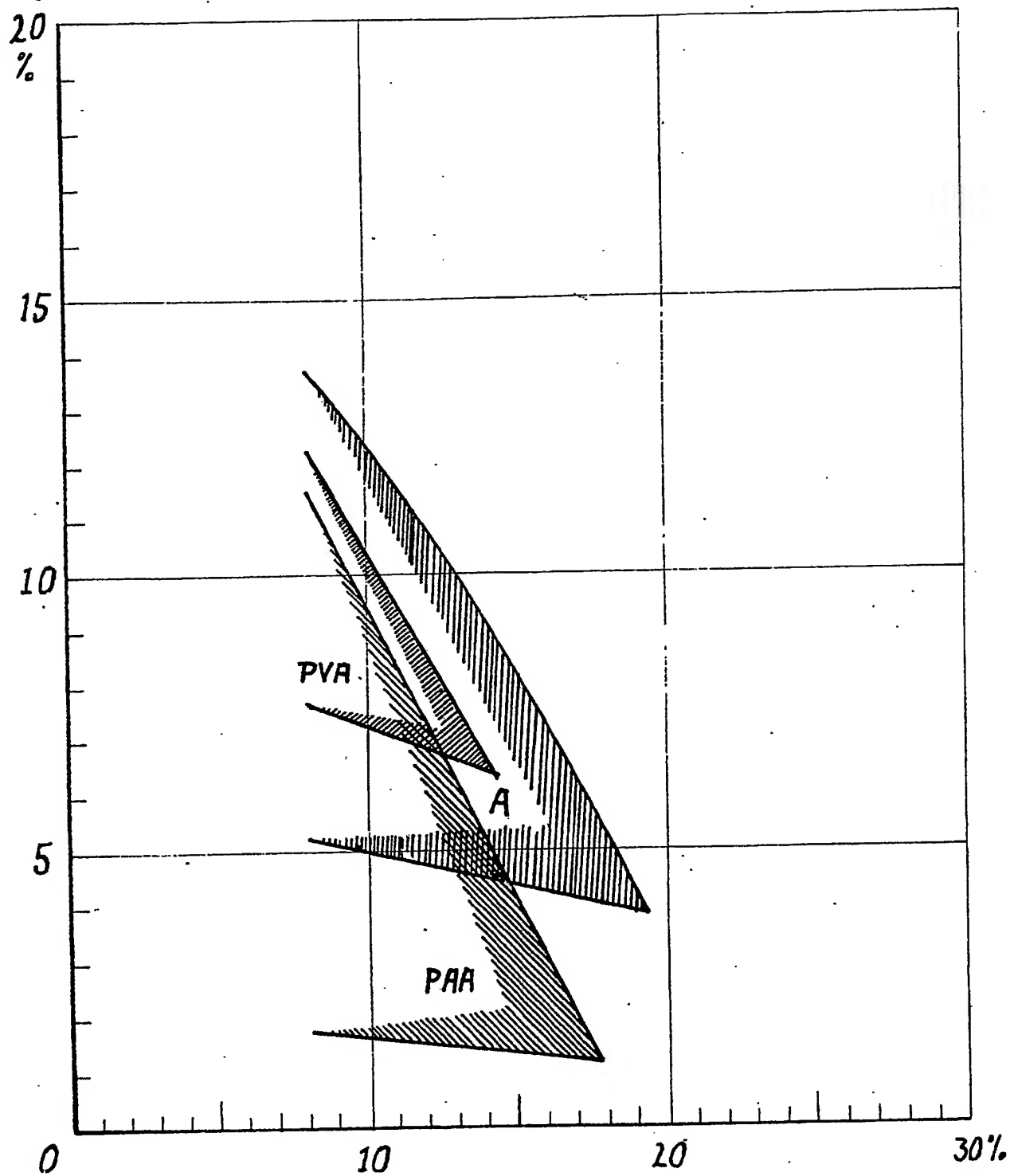
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Fig. 8



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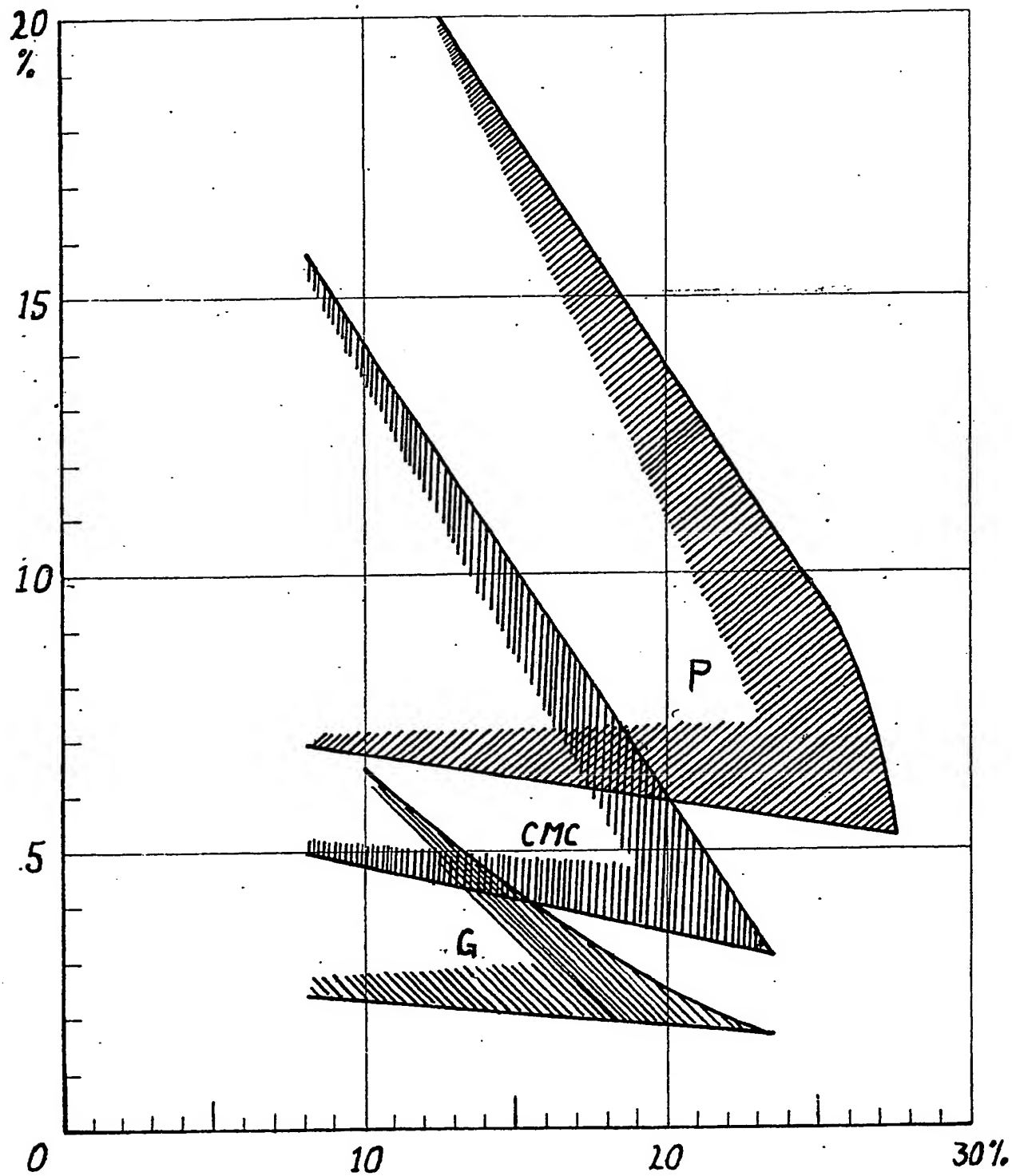
Fig. 9



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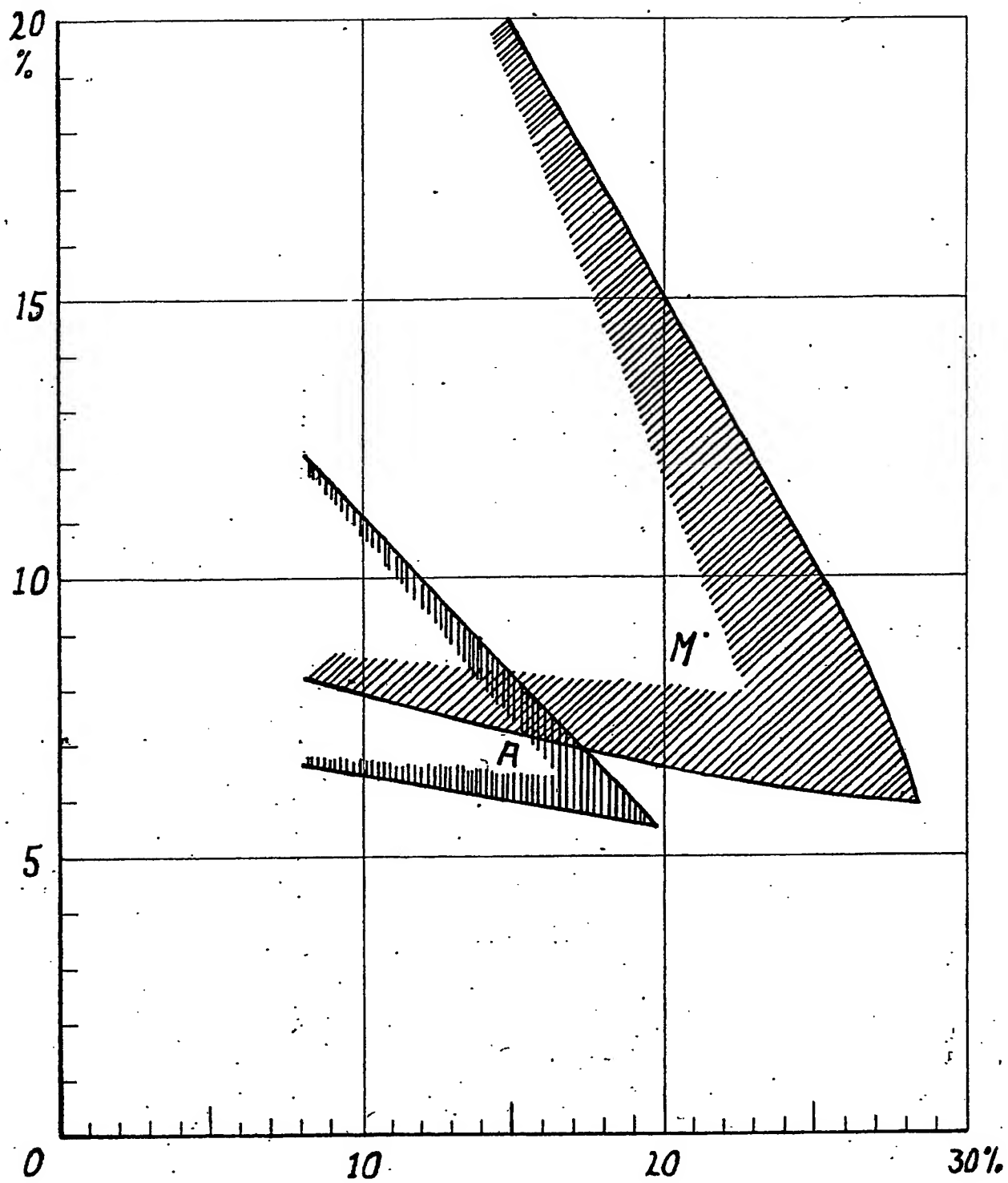
Fig. 10



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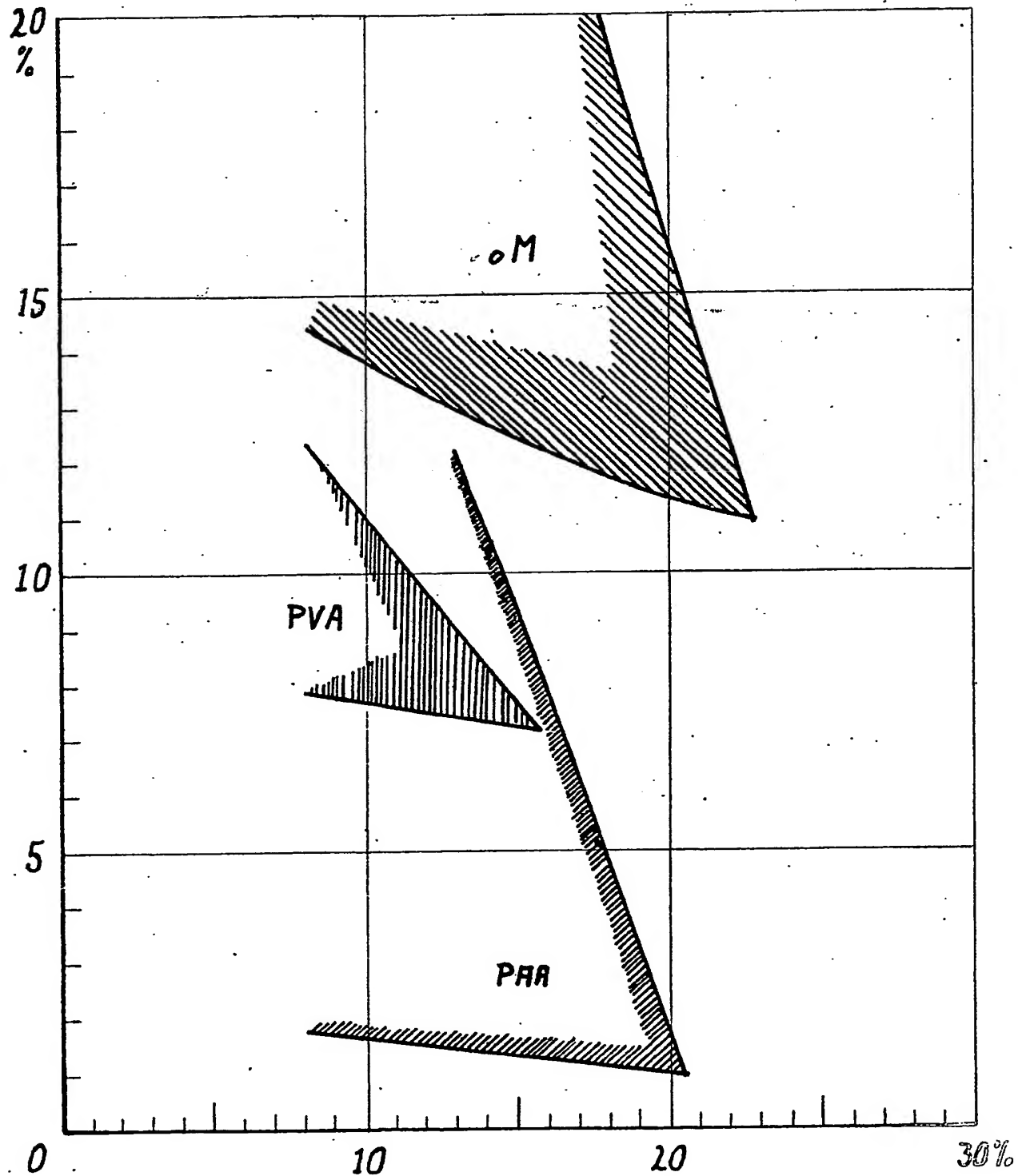
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Fig. 11



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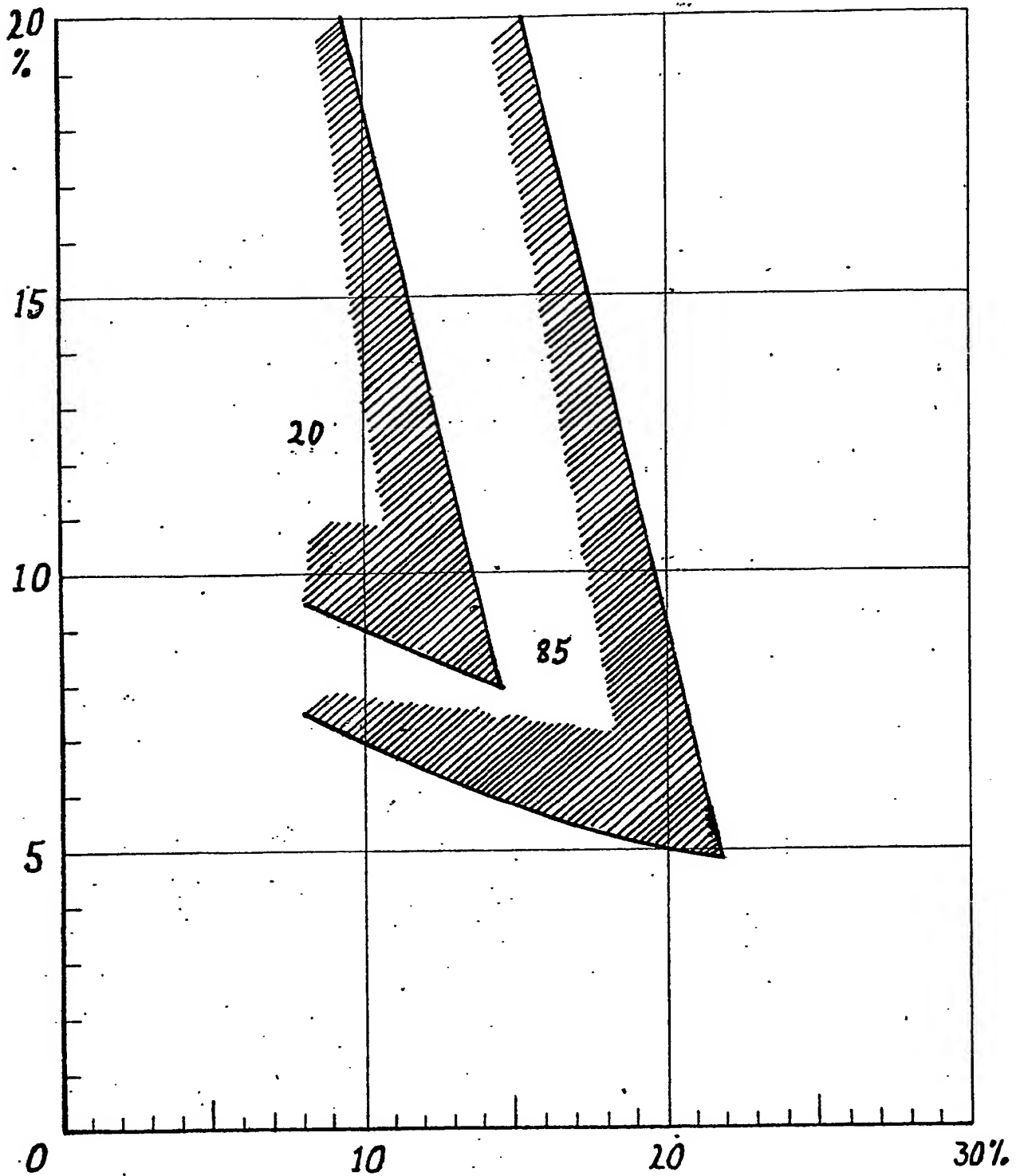
Fig. 12



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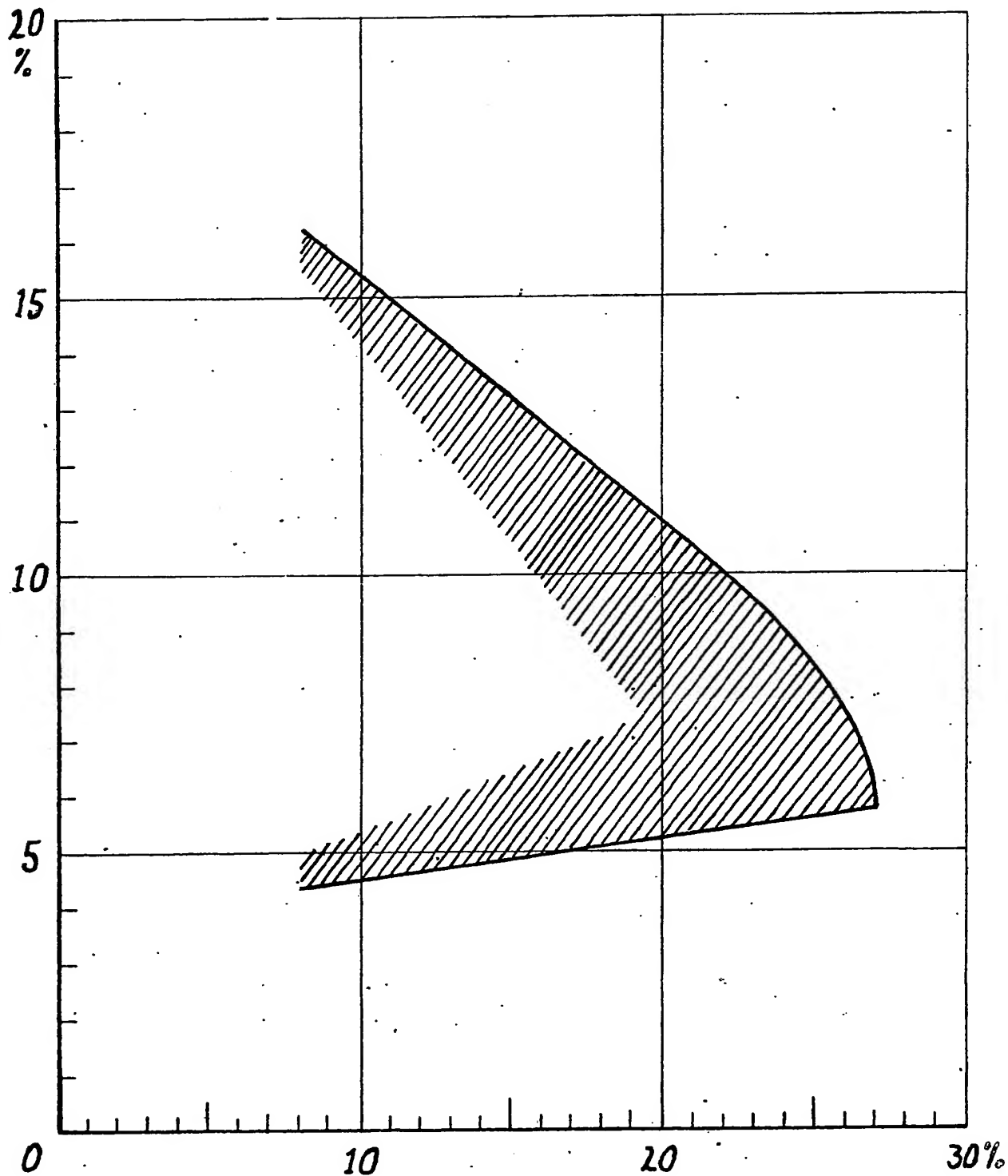
Fig. 13.



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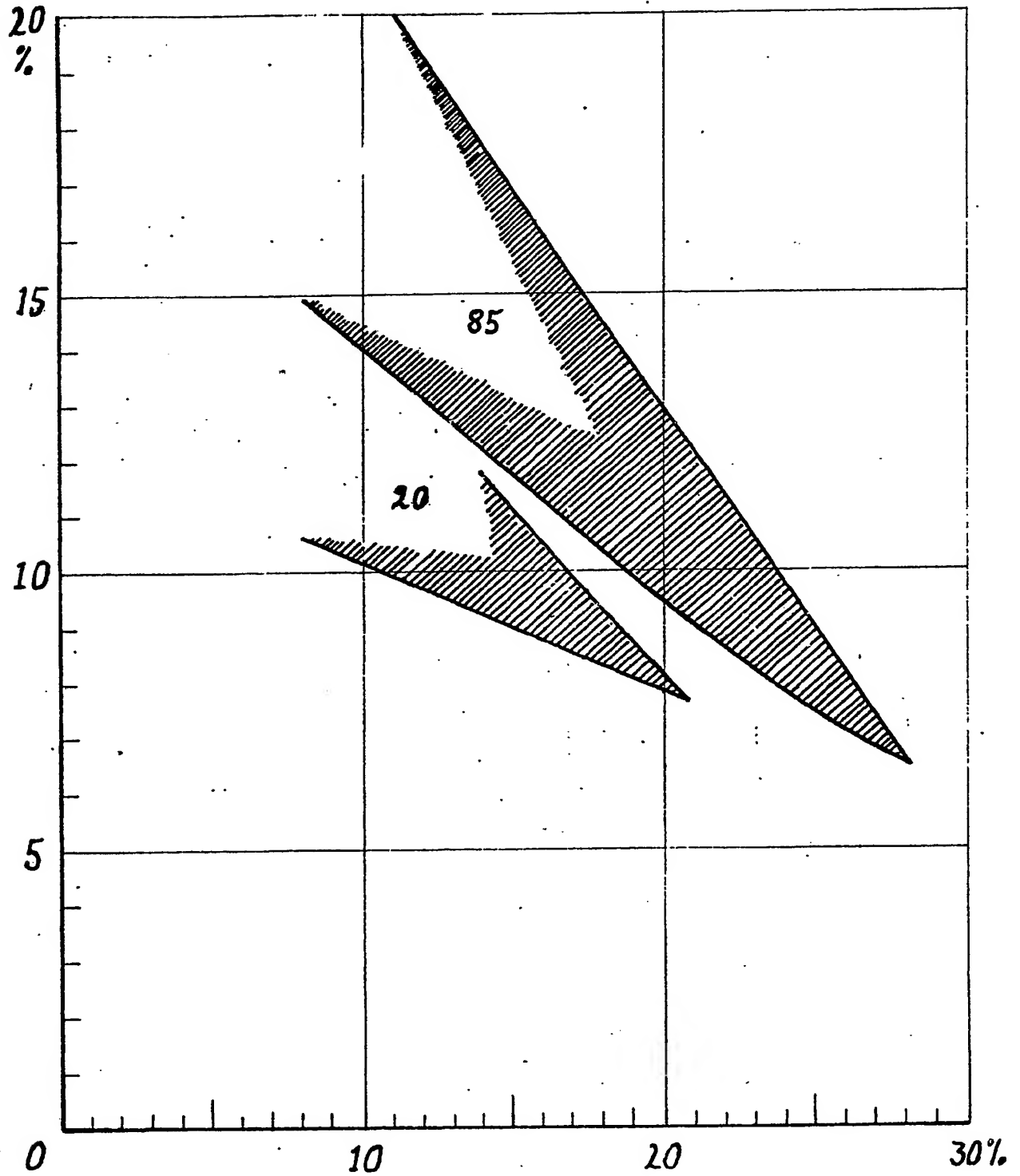
Fig. 14



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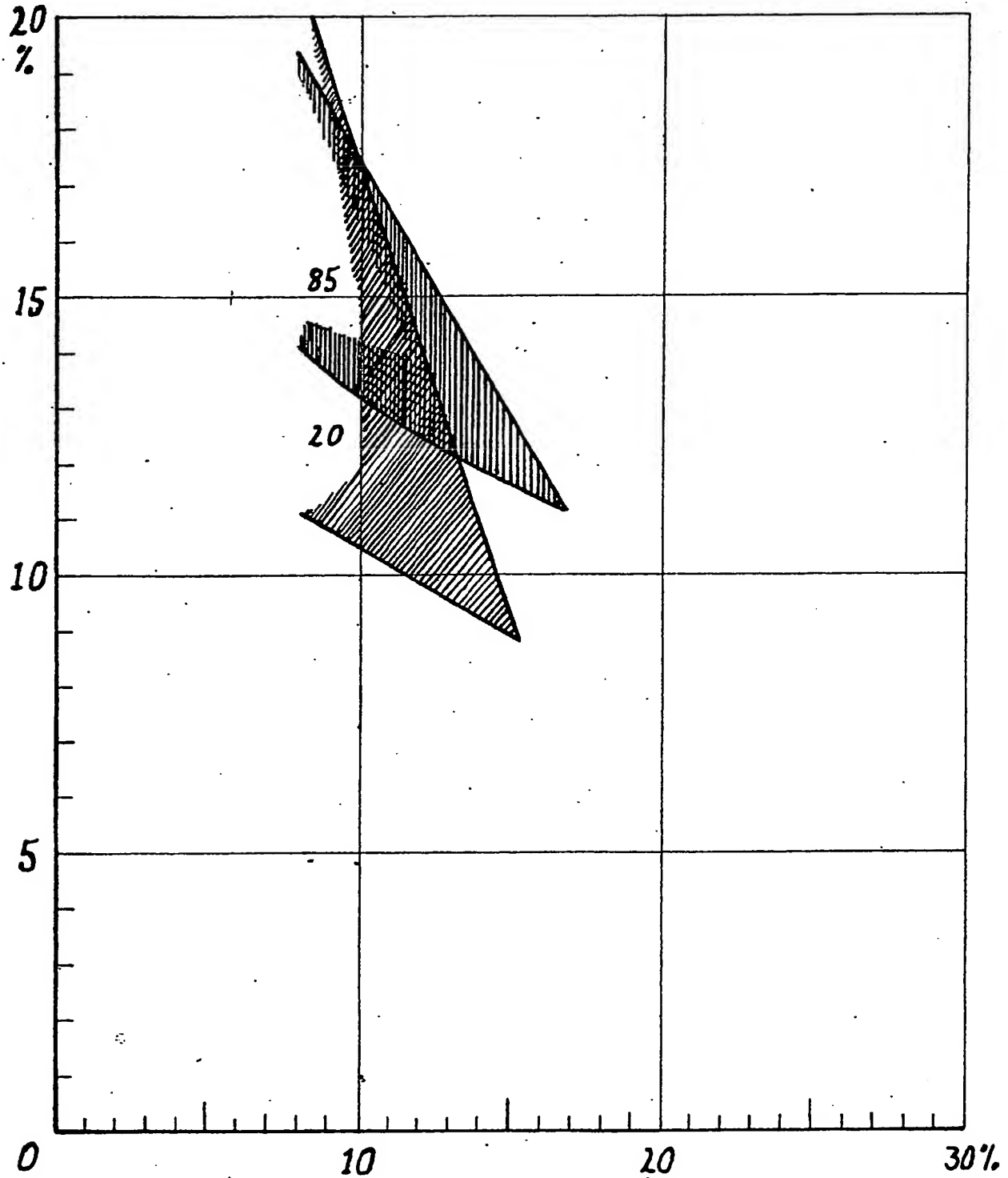
Fig. 15



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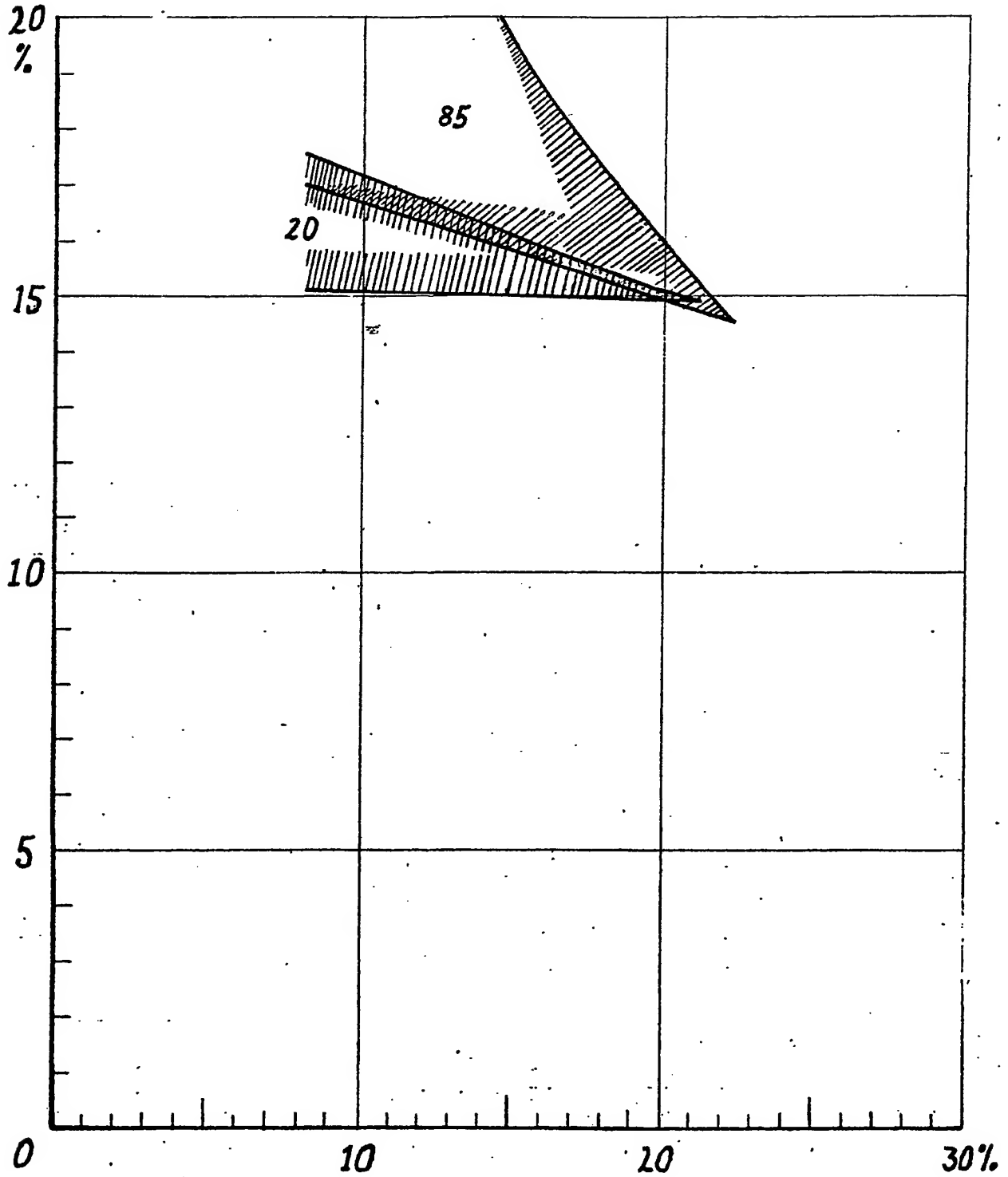
Fig. 16



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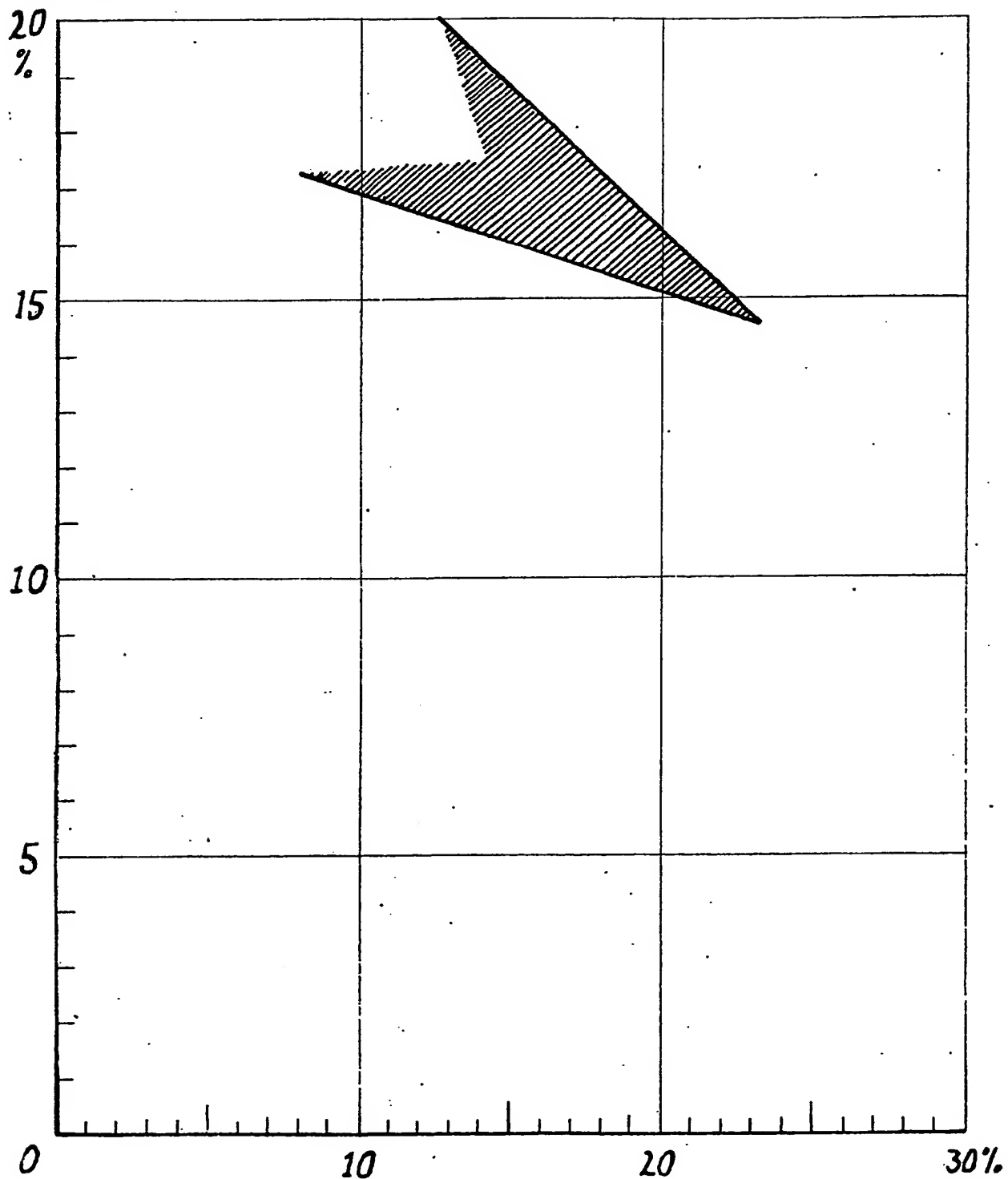
Fig. 17



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Fig. 18

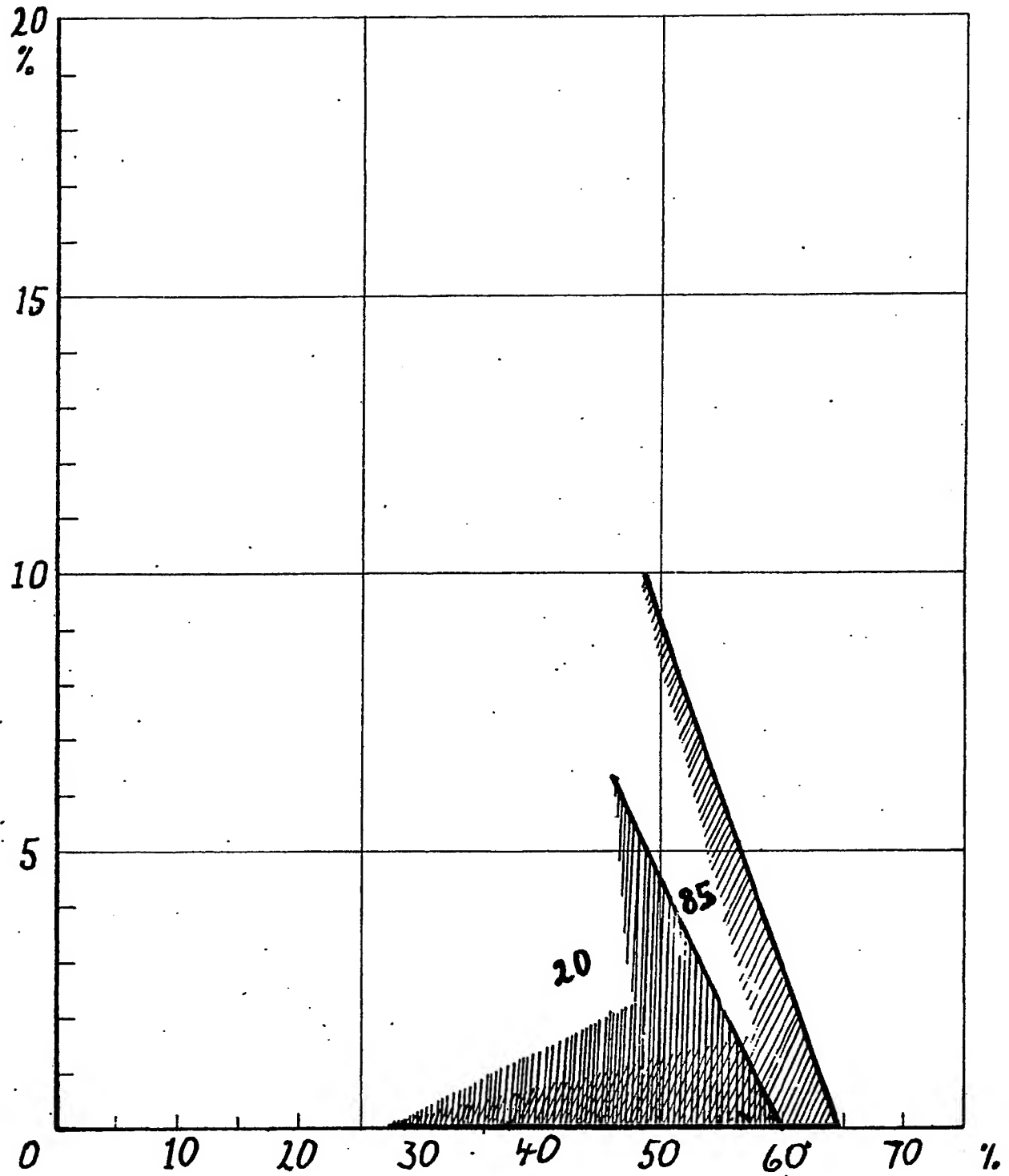
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Fig. 19



SPECIFICATION Moulding Paste

This invention relates to a moulding paste for producing of formed products particularly

5 products of wood fibers.

The traditional methods for the production of wood fiber products such as:—

the thinnest—"paper"

the intermediate type—"paper board"; and

10 the thickest—"particle board"

involve the use of a dispersion of the cellulose pulp or wood pulp or the wood particles in water at very low solid content. To achieve such even distribution of the fibers that paper or board of acceptable quality can be produced flocculation of the fibers has to be avoided, which makes it necessary to use so much water that its weight is about 200 times that of the fibers themselves.

Afterwards this water has to be removed:—

20 first by drainage through a wire mesh; thereafter by pressing;

and finally by evaporation with heat.

Paper, paper board and related products have now been produced in basically this way for almost 180 years. Handling of the large amounts of water and the necessity of cleaning of the effluent, which cannot be recirculated back into the process, have made the paper industry utilize giant units which have to utilize minimum 80% of the production capacity day and night the year around in order to pay the very high capital costs.

The reason why wood fibers are so suitable to produce paper and related products is their innate property of producing chemical bonds — hydrogen bridging — between each other when water evaporates and the dry content becomes more than about 70%. This imparts to the finished products their mechanical strength, which strength can be further improved by the addition of binders. The most common binder is a hydrocolloid, for example starch. The use of binders is becoming gradually more important as the industry is using gradually more waste fiber, which is recirculated back to the industry from the community, because the recirculated fibers do not possess the same strength potential as virgin fibers. Binder can be added at the wet end to become homogeneously mixed in between the fibers or it can be applied at the surface after web formation. Both methods, however, have their limitations. In particular, when added at the wet end, the binder has to adhere to the fibers at the point in the process where there is the highest quantity of water present, which means that it is necessary to use expensive surface active binders to prevent their leaking out of the system together with the water. Also other additives cannot give their optimum efficiency when added at the wet end, because of bad retention and also because all reactions are difficult to carry through at these low concentrations.

Surface applications are efficient to improve the surface characteristics of paper and board. The most common method for strength

65 improvement is the size press treatment by which the paper passes through a size press with starch solution after it has been dried to a dry content of about 95%. Size presses are only capable of handling thin low viscosity liquids and so the

70 binder has to be broken down in viscosity which unfortunately reduces the strength potential of the binder. It is also not possible to run with higher binder concentrations in the size press than 13%. The rest of the solution is water, which penetrates into the paper so that it becomes necessary to carry out the expensive drying by heat a second time. By pressing before the drying it is usually possible to reduce the water content to 2 tons per ton of finished paper, and in the size press it is normal to add about half a ton of water per ton of finished paper, which means that the total amount of water which has to be evaporated is about $2\frac{1}{2}$ times as much as the paper produced.

Because of the above limitations it is not 85 normal to use more binder than about 1/20 part of the paper produced.

From the patent literature can be seen that attempts have been made along two different lines to solve the problem of the large amount of water. These are (i) modest increase of 90 concentration, and (ii) completely dry web formulation. The methods involving modest increase in concentration fall under two headings:

1. By foaming it is said that the amount of 95 water can be reduced to about 100 times the amount of fibers.

2. Swedish Patent Nos 355615, 366787, 362458 and 385029 describe so-called high consistency formation by which it is said that the 100 water can be reduced to 25 times the weight of the fibers. When higher consistencies are used, the distribution of fibers is not sufficiently even.

Completely dry web formation of cellulose fibers is used for the production of so-called non-woven materials, for example as disclosed in U.S. Patent No 3575749. In this method, however, the great advantage which cellulose fibers have over other fibers, i.e. the ability to link by hydrogen bridging, is lost, and so it is necessary to use large amounts of synthetic binders such as styren-butadiene or acrylics.

Industrial production between the two extremes—very low consistency and completely dry production—has not heretofore been carried 115 out.

According to one aspect of the invention there is provided a moulding paste, suitable for the formation of formed products by plastic moulding comprising an aqueous suspension of a fibrous material, particularly cellulose fibres, for example wood or paper pulp, and a water-binding material.

The water-binding material preferably binds all of the water present, i.e. the amount of the material is such that when the paste is 125 compressed, free water cannot be expelled from its surface, and the paste is generally homogeneous.

I have also found that the addition of the appropriate amount of a water-binding material to

a slurry of a particulate material, for example coal dust, can yield a similar paste, which is susceptible of plastic moulding.

- According to a second aspect of the invention
- 5 there is provided a moulding paste, comprising an aqueous suspension of a particulate or fibrous material, and a water-binding material chemically binding substantially all of the water present.

- The water-binding material may be any
- 10 material capable of chemically binding water as described above, and such materials are commonly known as hydrocolloids. The terms "water-binding material" and "hydrocolloid" (or the abbreviated form "colloid") are used
- 15 synonymously throughout this specification.

The addition of the hydrocolloids to the dispersion may be carried out after de-watering of the suspension and before plastic formation of the products.

- 20 Suitable hydrocolloids are starch, starch derivatives, dextrans, polyvinylalcohol, cellulose derivatives such as carboxy-methylcellulose or hydroxyethyl-cellulose, animal protein such as casein, vegetable protein such as soya, vegetable
- 25 gums such as guar gum or locust bean gum, alginate, synthetic hydrocolloids such as polyacryl-amide or flour from different origins such as wheat, oat, rye, barley, corn etc. or from tubers such as potatoes or tapioca.

- 30 The hydrocolloid could be added after gelatinization in water or merely dispersed in water or any other liquid.

- The most suitable fibers are fibers from cellulose or ground wood. Also inorganic fibers
- 35 such as glass fibers, synthetic fibers such as polyester, polyamide or acrylics or mineral fibers such as asbestos may be used.

- Formation according to the invention can be done at different temperatures and also at
- 40 elevated pressures. Expansion can be accomplished during the formation by simultaneous development of gas or steam.

- Formation according to the present invention can be done by extrusion or injection-moulding by
- 45 machinery similar to those in the plastic industry, by coating with machinery similar to those in the plastic industry, in the paper and board industry and in the industry for production of building elements such as gypsum boards or through
- 50 rolling, pressing or drawing with machinery similar to those used in the metal industry.

- The invention is particularly advantageous for those concentrations of fibers and colloids, which appear from the curves on Figures 7 to 19, to be
- 55 described below.

- The addition of hydrocolloid in such an amount to completely bind the water turns the suspension into a surprisingly homogeneous plastic cohesive
- 60 paste of fibers, water and colloid. The properties of this paste is completely different from the properties of those fiber dispersions which are normally used for the production of fiber products. If such a traditional fiber dispersion is exposed to extrusion, injection moulding, rolling or pressing,
- 65 de-watering occurs and on extrusion or injection

moulding, the nozzles become plugged by de-watered fiber bundles.

- It will appear from the experiments to be described below that it is possible to reduce the
- 70 amounts of water present by formation to about 2 times the dry content which indeed is a considerable improvement compared to 200 times by traditional production of paper and paper board.

- 75 The colloid functions both as a process aid during formation by binding the water and preventing the fibers from flocculating and also as a functional aid for the finished product by giving strength and rigidity.

- 80 For the complete binding of water more hydrocolloid is needed than the amount normally used as binder by traditional methods. It will appear from the experiments to be described below that a normal amount of colloid is about
- 85 1/3 of the amount of fibers. The invention thus eliminates those limitations for addition of binders which are mentioned in the introduction above.

- The invention will now be illustrated with reference to the accompanying drawings, in
- 90 which:

Figure 1 shows apparatus for the production of paste according to the invention.

Figures 2 to 6 illustrate various forms of apparatus for plastic forming the paste, and

- 95 Figures 7 to 19 give the concentration limits for some fibers and colloids, which are considered particularly interesting for practical utilization of the invention.

- Figure 1 illustrates how fiber 1 can be
- 100 dispersed in water in a hydro pulper 2 equipped with a strong agitator 3. The agitation separates the different fibers from each other. The preparation of the dispersion can be divided into or completed with such in themselves known
- 105 steps as disintegration, deinking, defibration and refining. The dispersion is brought to the filter 4 for de-watering also by methods which in themselves are wellknown. The net supply of water to the process may conveniently be added
- 110 at the filter in order to further clean the fibers before they are—if desired—further concentrated by pressing 6. For high consistency, a screw press may be needed. The water separated from the filter may be recirculated to the pulper 7 possibly
- 115 after cleaning. Impurities which arrive with the fiber may be taken away by different in themselves well-known separation processes in the pulper itself or on the course to the filter. After de-watering to the desired concentration the hydrocolloid is added 8. The hydrocolloid is mixed
- 120 into the fiber suspension by strong kneading through which a paste 9 ready for formation is prepared. Formation may be done in separate equipment or possibly through extrusion directly
- 125 from the kneading apparatus. The temperature can be controlled during formation at point 10.

- Figure 2 illustrates formation by an extruder
- 130 11. The temperature in the extruder is controlled by heating or cooling. It shall later be shown that elevated temperatures give the possibility of

formation at higher concentrations. After formation the first drying may be performed by radiation or convection 12, after which the extruded profile is laid down onto heated forming boxes. A hood may be provided above the moving forming boxes or moulds in order to recover the heat in the air used for drying. This is not shown on the drawing. When the forming boxes move away from each other at 13, the web is divided into the desired length and when the drying is completed the produced articles are loosened from the forming boxes for example by pressurized air 14. Before new paste is laid onto the forming boxes they may be cleaned and prepared in other ways. Figure 2 illustrates extrusion of a profile, but it is of course also possible to use a wide flat extruding nozzle in order to produce flat sheets which afterwards can be dried and converted by similar machinery as for traditional types of board.

Figure 3 illustrates intermittent extrusion into moulds. In the plastic industry this is called injection moulding. The upper part of the mould is permanently connected to the extruder 11 and the lower part 15 is also used to transfer the billets to the drying equipment 16. A hood above the drying equipment in order to recover heat is not included in the drawing. The billets are loosened from the drying equipment at 11 for example with pressurized air. During the drying the billets shrink and so they have to be pressed into the correct size at 18.

It is possible to produce porous products by incorporation of additives which release gas—usually hydrogen, carbon dioxide or nitrogen—or by performing the extrusion with paste at temperatures higher than 100°C against normal air pressure after the extruder. The expansion can also be accomplished by foaming. Packaging materials with a hard outer surface and a soft shock-absorbing inside may be produced by keeping the two sides of the mould at different temperatures. Sandwich-constructions with an expanded center and compact surfaces may be produced by keeping both surfaces cool during the formation while the center maintains its high temperature. Basic techniques from the manufacturing of foamed plastics can be applied.

Building elements such as boards may be produced according to the invention as illustrated on Figure 4. The paste 9 arrives from a headbox 18 and is spread out on a forming board 19 between two covering layers 20, e.g. of paper. The paste may possibly be predried on the forming board e.g. by the aid of radiation. The main drying is accomplished in a long drying oven 21 during which the hydrocolloid migrates together with the water towards the two surfaces and acts as a glue towards the covering layers. Finally the board is cut into suitable sizes 22. By expansion as described above the desired compromise between strength, heat-insulation and sound-insulation can be obtained.

Figure 5 illustrates an example of coating with paste 9 prepared according to the present

invention. It is thus possible to combine the fibrous product for example with a film of plastic 20. After application the paste is levelled out 23 and dried 24.

It is not essential, in the embodiments shown in Figures 4 and 5, that all of water in the paste is chemically bound by the hydrocolloid, since in these embodiments the paste is not extruded through a die or nozzle, and hence the problem of blocking of the orifice by dewatering does not arise.

A flat web prepared according to the present invention may when it is still moist and therefore flexible be laid onto moulds for manufacturing for example of disposable plates.

A wide range of articles may also be produced using the paste of the present invention, for example, various packaging materials such as cartons, food trays for use in the retail trade, and various extruded sections such as tubes.

Articles manufactured according to the present invention may also be combined with other materials after drying for example by applying decorative films or decorative printing, and on top of this may also be applied a clear lacquer for example of acrylic, PVC or polyurethane. A box manufactured according to the invention may be covered with decorative paper or lined on the inside with waterproof materials.

The amount of colloid needed to completely bind the water according to the present invention is higher than the amount of colloid used for strength improvement according to traditional manufacturing methods as indicated above. At a first view this high amount of binder may be interpreted as a disadvantage of the present invention because additives are commonly considered to increase costs. For the present invention, however, this is not the case. The most common colloid starch costs about the same as cellulose. If then the cellulose needed by other manufacturing methods to achieve the same strength is substituted with starch and cheaper fibers of lower strength the raw material cost per ton is reduced and the starch compensates for the lower strength potential of the cheaper fibers. The only type of paper or board which in stiffness and rigidity may be compared to products manufactured according to the present invention is laminated board, which is made in two manufacturing steps: First production of the individual paper layers and then usually in another mill to glue these layers together. Experimental sheets made according to the present invention in the basic weight area 400—1200 grams per m² were compared by measurement of stiffness with commercially laminated board. It appeared that only the most expensive types of laminated board were able to show the same stiffness at equal area weight as the present invention gave with old newspapers as fibers and normal corn starch as colloid. To achieve such a stiff laminated board it is necessary to use papers made from virgin kraft pulps and these papers cost about £210 per ton. When using the present invention it is

possible to achieve the same stiffness by extrusion of a paste composed of 23% newsprint waste at a cost of about £20 per ton and 8% starch (see Figure 11) at about £200 per ton, which means that the average raw material cost is about £70 per ton. It is therefore with the present invention possible to reduce raw material cost to about 1/3 of the normal with traditional methods—and to maintain rigidity.

Corrugated board is a good method of producing packaging materials and which was invented by Albert L. Jones in 1871, U.S. Patent No 122023. The rigidity of the board compared to the amount of material used is high by making the center hollow and surfaces compact. The most important property is the ability of high piling height of the filled corrugated boxes. This is accomplished by having the corrugations run vertically in the walls of the boxes and also by using stiff paper in the center corrugated layer—the fluting medium. By the production the base papers—the fluting for the center and the two liners for the surfaces—it has, however, not been possible to carry through this orientation of the stiffness. A paper machine is able to orient the fibers to some extent in the machine direction to achieve orientation of the stiffness in this direction but not in the cross direction. At corrugated board mills the papers are handled in continuous webs and the corrugations therefore unfortunately are in the opposite direction of the highest stiffness of both fluting and liners. This disadvantage is further strengthened by the fact that the corrugated board mills by bending the paper to make flutes destroy some of the stiffness, which the paper mills endeavoured to incorporate into the fluting.

These disadvantages are eliminated if the present invention is used for production of corrugated board, e.g. as illustrated on Figure 6:

The fibers in the liners 20 are oriented in the same direction as the corrugations.

The fluting is extruded as a paste according to the invention from an extruder 11, which has a profile to achieve the desired corrugations and the fibers can in this way to some extent be oriented along the corrugations.

The stiffness of the fluting is not destroyed by bending after it has been formed.

Before the two liners 20 have been applied there may be a predrying by radiation 12. The main drying is carried out in a long oven in a similar way as by traditional production of corrugated board 21. By traditional production the corrugations are in cross direction whereas by the present invention they may be in machine direction as shown in section 25. If the drying oven is in an inclined position the evaporated steam may be carried away by natural convection 26.

During the drying the colloid migrates in the fluted layer together with the water out towards the liners and accomplishes adhesion between the top of the flutes and the liners so that the use of adhesive may be dropped. Another very

important improvement is the possibility of achieving high wet stiffness by the addition of wet strength aids, because the amount of starch in the fluting layer is higher than traditionally and the wet strength aids are more efficient on starch than on cellulose. Finally the commercial aspects should not be forgotten. The raw material cost for fiber products according to the present invention is about £70 per ton as shown above. The corrugators are today buying their base papers at prices in the line of £210 per ton.

The corrugated board may according to the present invention be manufactured in many different ways from that illustrated on Figure 6. It is, for example possible also to make the liners according to the invention from extruders making a flat web.

Because of the high amount of binder the method of the present invention is particularly interesting for the production of articles where rigidity, and appearance more like wood than paper increases the market value, for example for many different packaging purposes. The invention is also particularly interesting for the production of hollow articles, as this is awkward with the traditional methods, where it is necessary to start from flat sheets. On the raw material side the invention is particularly interesting for the recirculation of newsprint waste. This waste paper is because of its low potential strength and slow drainage not attractive to other methods where waste fiber is used, is and therefore cheap. Later on it shall be shown that with newsprint waste it is also possible to use less colloid to achieve complete binding of water than with longer fibers.

In those cases where a more tough and flexible end product is required the hydrocolloid may be combined with a synthetic binder f.inst. latex of styren-butadien, acrylic or vinyl-acetate.

To prevent penetration of water natural and synthetic resins may be added. To increase wet strength the efficiency of such resins as ureaformaldehyde and melaminformaldehyde is remarkably good. Other additives may be fillers as clay and chalk and pigments as titaniumdioxide. Further dye and fireretarders may be added.

The drying rate may be improved by adding fillers which make the paste more porous or by adding products which absorb water, such as burned gypsum or cement.

In those cases where a still more rigid product is needed than by the use of only hydrocolloid the hydrocolloid may be combined with other binders, for example cement.

The invention is, also, applicable for other types of particles dispersed in water. In the traditional production of ceramics, china and cement products the ability of some minerals such as clay to bind water is utilized in order to obtain a homogeneous paste, which may be plastic formed. By addition of a hydrocolloid according to the present invention such methods of forming are not any longer limited to those minerals, which in themselves bind water. It will

thus be possible to make articles of quite new compositions. The method may in the future obtain great importance for the production of bricketted firing material particularly bricketted

fuel formed by using the present invention to convert water dispersions of powdered coal or other cheap combustible material into pastes, which are then formed to bricketts or other shapes suitable for distribution and automatic heating.

Trials have been performed with an injection moulding machine type Demag Stübbe S 55 d, which is normally intended for plastics. The machine had a nozzle with diameter of 3 mm. No difficulties were encountered by extrusion of a string of paste out of this nozzle and into a mould with a flowing distance of 250 mm and a material thickness of 2 mm. By leaving a narrow fissure of 0,3 mm between two parts of the mould a film was extruded which after drying has a thickness of 0,2 mm. It appeared that the necessary precautions for troublefree injection moulding and film extrusion were:

Completely binding of the water in the paste. With insufficient amount of hydrocolloid, dewatering occurred in the nozzle which left this plugged of fiber bundles.

Acceptable flowability. With too high concentrations of hydro-colloid boundaries were detected inside the formed articles.

The experimental products produced were in appearance—particularly with regard to stiffness, rigidity and rattle—somewhere between wood and stiff paper board.

In order to establish the limitations in concentrations during formation many experiments were performed with different types of dispersed particles and colloids. The minimum and maximum amount of colloid to make an extrudable paste was measured at the laboratory at different fiber concentrations. For this work 2 criteria were chosen:

1. Maximum Amount of Hydrocolloid:

A Haake consistometer was used. This is a viscosimeter which measures the resistance for flow through a 2 mm hole drilled in a piston. Temperature of the paste is controlled by a thermostat. The viscosimeter is used in the plastics industry for measuring the viscosity of thermo-plastics after melting. The viscosity is calculated from the equation

$$\eta = \frac{G \cdot t}{s} = K$$

where η = viscosity in Pascal seconds

G = load in kp

t = time in seconds

s = measuring distance in mm

K = constant for the apparatus with hole of 2 mm = 2,5

A figure of 10000 Pascal seconds were chosen as the criterion for extrudability. This is in the

plastic industry considered quite high but not difficult to extrude.

2. Minimum Amount of Hydrocolloid:

The same Haake consistometer was used to establish the amount of colloid needed to obtain complete binding of the water. The first sign of incomplete binding (synaesis) was a glossy surface of free water on the surface of the extruded string.

By using these two criteria diagrams 7—19 were drawn. Fiber concentration is plotted along the horizontal axis and colloid concentration along the vertical axis—both in weight percentages of the entire paste. The difference up to 100% is water. The lower line gives the minimum criterion and the higher line the maximum. The two lines combine to an angle and the invention is practicable within this angle.

In Figures 7—9 the fiber is recirculated newsprint and the extrusion temperature 20°C. The indications used for the colloids are

koM = coldwater soluble oxidized corn starch Amijel M 5 from CPC

P = native potato starch

G = Guar gum, SuperCol U Powder from General Mills

oM = Oxidized corn starch, Amisol 05594 from CPC

M = Native corn starch

CMC = Carboxymethylcellulose, Majol PS 6 from Uddeholm, Sweden

PVA = Polyvinylalcohol, Covol 9930 from CPC

PAA = Polyacrylamid, GR from W R Grace

It can be seen e.g. from Figure 8 that at a fiber concentration of 16% 7% corn starch is needed as colloid to completely bind the water. By increasing the amount of colloid the paste becomes less fluid and at 10% colloid the paste is so thick that the possibility of extrusion without particularly strong machinery may be doubted.

Native corn starch and pregelatinized corn starch gave the same curve M. For potato starch it appeared that the pregelatinized starch gave the two criteria at lower amounts than native starch and the tip of the angle indicating maximum possible fiber concentration moved a bit to the left. However, after vigorous agitation both viscosity and water binding returned to the values for native potato starch and only the curve for native potato starch has been drawn P.

On Figure 10—12 the fiber still is newsprint waste but the extrusion temperature was increased to 85°C. The colloids are

P = native potato starch

CMC = carboxymethylcellulose, Majol PS 6 from Uddeholm, Sweden

G = guar gum, SuperCol U Powder from General Mills

M = native corn starch

A = alginate, Protanal H from Protan & Fagertun, Norway

oM = oxidized corn starch. Amisol 05594 from CPC

PVA = polyvinylalcohol, Covol 9930 from CPC

PAA= polyacrylamid, GR 999 from W R Grace

The tip of the angles indicates how high fiber concentration it is possible to process according to the two chosen criteria. By comparing the

- 5 curves for corn starch M on Figure 8 and Figure 11 it can be seen that the increase of extrusion temperature from 20 to 85°C makes it possible to increase fiber concentration from 20 to 28%. The necessary colloid concentration at 85°C and
- 10 maximum fiber concentration is 6%, which means that the remaining quantity water is 66% or about 2 times the dry content. Extrusions were also performed at higher temperatures than the 85°C which is the maximum temperature used for the
- 15 diagrams. With the equipment used it was, however, not possible to measure the criteria for minimum and maximum colloid because of vigorous steam development. Extrusion was carried out at 140°C of a paste composed of 41%
- 20 newsprint waste as fiber and 6% native potato starch as colloid, so that the ratio water to dry content was below $1\frac{1}{2}$. The energy needed for drying may therefore by the present invention be reduced compared to traditional production of
- 25 paper and paper board. The potato starch was added to the fiber dispersion without preceding cooking and therefore gelatinized by the aid of the heat immediately before being extruded. Extrusion through a 2 mm nozzle gave no
- 30 difficulties. After passing through the nozzle and paste expanded by steam development into a filamentous network which after drying showed a specific gravity of 0,2 kg/dm³ against 0,8 kg/dm³ for normal extrusion at temperatures below
- 35 100°C.

In Figure 13 the fibers still are newsprint waste but instead of using a pure hydrocolloid ordinary wheat flour made at the yield of 78% was used. The extrusions were as before made at 20 and

- 40 85°C. The diagrams show that the maximum possible fiber concentration is lower for wheat flour than for the starches.

In Figure 14 the fiber is newsprint waste and the colloid native potato starch, but before measuring of the criteria 4% of a 50% styrene-butadien latex, DL 675 from Dow was incorporated. In this diagram therefore an the amount of water is the difference between 98% and the sum of the concentrations of fiber and colloid, whereas the amount of water at all other diagrams can be found as the difference up to 100%. The temperature was 20°C. By making a comparison with the diagram for potato starch on Figure 7 it can be seen that the latex contributes

- 55 to the water retention and also makes the paste more free-flowing, and so the lowest line moves downwards and the point for maximum fiber concentration to the right.

In Figure 15 the fiber is unbleached kraft waste from multiwall paperbags and the colloid is native corn starch. The extrusions were performed as usual at 20 and 85°C. The trials demonstrated that this fiber—sulphate pulp—because of its lower waterbinding property and also greater

- 65 tendency for flocculation needed more colloid

than newsprint waste to fulfil the minimum criterion and so the lowest line moves upwards on the diagram. This appears by comparing with the curves M on Figure 8 and 11.

- 70 Figure 16 illustrates the border lines for extrusion of mixtures of fiber from newsprint waste and casein as colloid. The casein which was used was Polish 30 mesh lactic casein. To improve the solubilization of the casein it was added as a dry mix of 53% casein, $10\frac{1}{2}$ % sodium carbonate (Na₂CO₃) and $36\frac{1}{2}$ % moisture. When Figure 16 was drawn the sodium carbonate was included as colloid.

- Figure 17 illustrates the result of extrusions where native corn starch was used to make pastes from water dispersions of glass fiber.

- Figure 18 illustrates that the paste according to the invention may also be used with synthetic fibers. The fiber used was polyamid perlon x 400 weiss h matt dtex 2,2 dtex 6 mm from Bayer, Germany, and the hydrocolloid coldwater soluble corn starch. For this fiber the curves at 20 and 85°C were surprisingly close to each other and the curve on Figure 18 was measured for both

- 90 temperatures.
- Figure 19 illustrates experiments with finely ground coal dust intended for foundries and wheat flour. It was possible to use much higher concentrations than with fibers and at these high
- 95 concentrations the water binding property of the coal dust was so good that the purpose of the wheat flour is more to give strength to the resulting bricketts.

- Extrusions through the Haake-consistometer and all other formation was easiest to perform midway between the 2 criteria and not too close the tip of the angle showing maximum dry content. Close to the line of the minimi-criterion and close to the tip for maximum dry content the paste and the ready products had a granulated appearance—less so for ground wood than for kraft pulp.

- The amounts of fiber and colloid on the diagrams are as dry. Moisture added to the system together with the fiber and the colloid is calculated as water. The moisture content for all other colloids than starch and wheat, however, was so low that it has not been taken into consideration.

- 115 The methods used for making the experiments are given below.

- The fiber to be used was dissolved in warm water at 2% concentration and vigorous agitation. The produced pulp dispersion was dewatered through a wire mesh with $\frac{3}{4}$ mm between the threads, and was thereafter pressed by hand to a dry content between 10 and 35%.

- It appeared to be extremely important always to use the same temperature-time-lapse for preparation and storage of the paste before measurement of the criteria as otherwise variations appeared in the results. Different methods were used for warm water soluble and cold water soluble colloids:

Method for Warm Water Soluble Colloids

About 200 g of a fiber dispersion with colloid added in such an amount to try to "hlt" the criterion looked for was placed in a closed glass jar in an oven at 110°C for 10 minutes. The temperature of the oven was then reduced to 95°C at which temperature the sample was left for 30 minutes, after which the jar was opened and after fast agitation the contents was tested for viscosity and waterbinding at 85°C. The rest of the sample was left for a further 60 minutes in the closed jar now at room temperature—whereafter the same two criteria were measured at 20°C. If the samples were left for longer periods of time than 60 minutes at room temperature lower water binding and higher viscosities were produced.

The diagrams for corn starch, oxidized corn starch, potato starch, wheat flour, polyvinylalcohol, alginate, CMC and guar are plotted in the diagram after measurement in this way even if the last mentioned 3 colloids really are cold water soluble, so that the method below also could have been used.

25 Method for Cold Water Soluble Colloids

Cold water soluble colloids are apt to give lumping by the addition to the fiber dispersion. To avoid plugging of the hole in the viscosimeter it was necessary to sprinkle the colloid very evenly, carefully and slowly onto the surface of the fiber dispersion when this is kept moving under vigorous kneading. 200 g samples were used also by this method. Measurement of viscosity and water binding at 20°C was carried out immediately after addition of the colloid. The rest of the sample was left for 90 minutes in an oven at 95°C before measurement of the two criteria also at 95°C.

This method was used for cold water soluble corn starch, cold water soluble oxidized corn starch, cold water soluble potato starch, casein and polyacrylamide. If the method is used for CMC and guar about 1% more colloid is needed than by the "warm water soluble method" used for plotting the diagrams probably because the colloids are more completely soluble by heating.

If the drying of the samples is performed in an oven at 105°C in such a way that 1 mm thick sheets of paste are placed to be dried on an untreated iron surface some difficulties can arise in loosening samples from the iron surface after drying. The experiments showed that loosening was easiest when a large amount of colloid has been used and when the colloid chosen was efficient for the binding of water i.e. to work in the area close to the maximum criterion of Figures 7—19.

When the samples were dried instead on a heated plate, the problem of loosening was considerably reduced. By testing cross sections of the sheets it was possible to demonstrate a concentration of the hydrocolloid in the surface towards the heating plate. This confirms the above mentioned theory that loosening is easiest

65 when there is a high amount of colloid.

The large amount of colloid in the surface to which the heat is added to the sample may be explained by migration of the colloid together with the water towards the hot surface where the water evaporates and the colloid is locked because it is not able to migrate back together with the steam.

If the drying is performed on a surface covered with polytetrafluoroethylene, there is no problem at all in loosening the dried fiber products.

Claims

1. A moulding paste, comprising an aqueous suspension of a fibrous or particulate material, and a water-binding material chemically binding substantially all of the water present.

2. A paste as claimed in claim 1, wherein the fibrous material is wood fiber, synthetic fiber or inorganic fiber.

3. A paste as claimed in claim 2, wherein the fiber is cellulose fiber, polyester fiber, polyamide fiber, acrylic fiber, asbestos fiber or glass fiber.

4. A paste as claimed in claim 3, wherein the fibrous material is newsprint pulp.

5. A paste as claimed in any one of claims 1 to 4, wherein the particulate material is a pulverized mineral.

6. A paste as claimed in claim 5, wherein the mineral is clay, chalk or coal.

7. A paste as claimed in any one of claims 1 to 6, wherein the water-binding material is starch, a starch derivative, a dextrine a polyvinylalcohol, a cellulose derivative, an animal protein, a vegetable gum, a vegetable protein, alginate or a synthetic hydrocolloid, or a vegetable flour.

8. A paste as claimed in claim 7, wherein the water-binding material is carboxymethylcellulose, hydroxymethylcellulose, casein, guar gum, locust bean gum, a polyacrylamide, wheat flour, oat flour, rye flour, barley flour, maize flour, potato flour or tapioca flour.

9. A paste as claimed in any one of the preceding claims, having a water content of not greater than 90% by weight.

10. A paste as claimed in claim 9, having a water content of not greater than 85%.

11. A paste as claimed in claim 10, having a water content of not greater than 80%.

12. A paste as claimed in any one of the preceding claims, which also comprises one or more of a softener, a natural or synthetic resin, a filler, a pigment, a dye and a fire retardant.

13. A paste as claimed in claim 1, wherein the amounts of the particulate or fibrous materials and the water-binding material are such that the composition of the paste falls within one of the shaded areas in any one of Figures 7 to 19 of the accompanying drawings, and the water-binding materials are as described in the portion of the foregoing description relating to the said shaded area.

14. A moulding paste substantially as hereinbefore described.

15. A process for the manufacture of a formed

product, which process comprises plastic forming a paste comprising an aqueous suspension of a fibrous or particulate material, and a water-binding material.

5 16. A process as claimed in claim 15, wherein the paste is as claimed in any one of the preceding claims.

10 17. A process as claimed in claim 15 or claim 16, wherein the plastic forming is carried out by extrusion, injection moulding, coating, rolling, pressing or drawing.

18. A process as claimed in any one of claims 15 to 17, wherein the formed product is caused to have a cellular structure by the generation of

15 gas, liberation of steam or by foaming, during the forming process.

19. A process as claimed in any one of claims 15 to 18, wherein the formation is carried out at elevated pressures and temperatures.

20 20. A process for the formation of a formed product, substantially as hereinbefore described with reference to any one of Figures 1 to 6 of the accompanying drawings.

25 21. A formed product when produced by a process as claimed in any one of claims 15 to 20.

22. A product as claimed in claim 20, which is a plate, a carton or a tube.

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